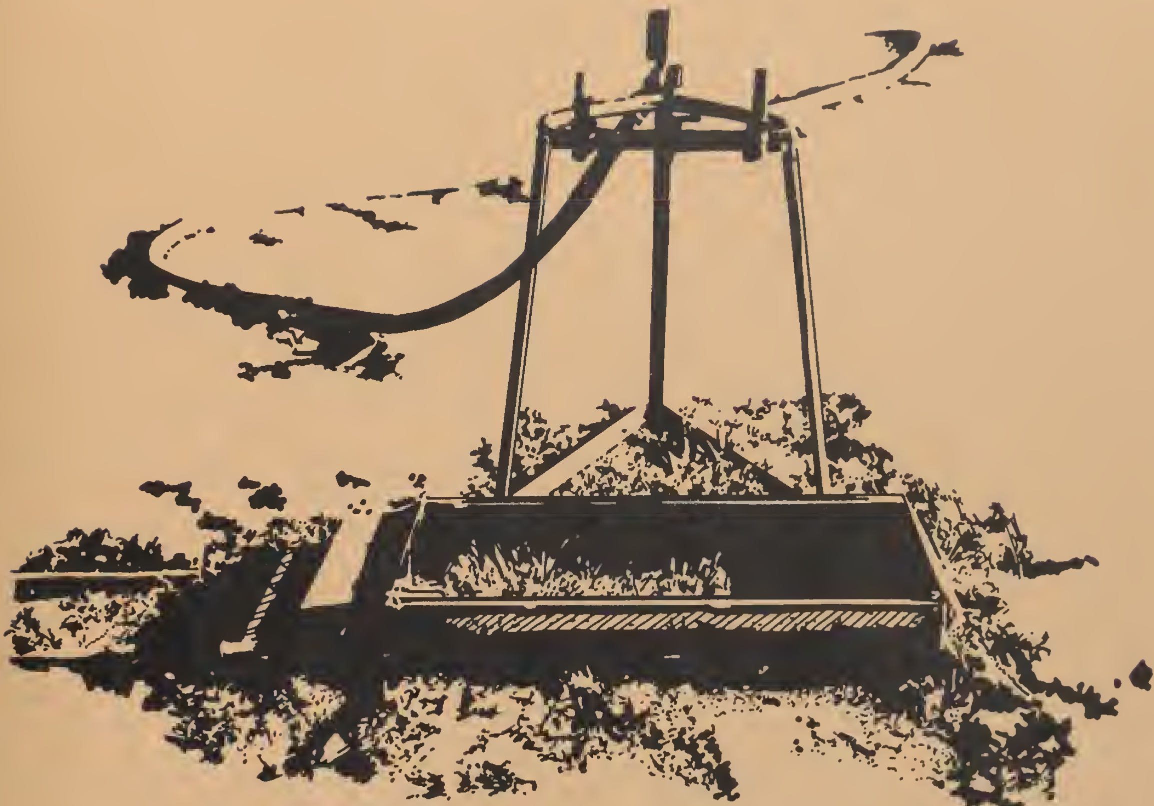
TECHNICAL NOTE 371



DETERMINING HYDROLOGIC PROPERTIES OF SOIL

by

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USDI Bureau of Land Management

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DETERMINING HYDROLOGIC PROPERTIES OF SOIL

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Reynolds Creek Technology Transfer Project
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DETERMINING HYDROLOGIC SOIL PROPERTIES

INTRODUCTION

This technical note provides resource specialists with tools for estimating soil properties required by many of the state-of-the-art hydrology, erosion, and sediment yield procedures and computer models. Some of the hydrologic soil properties will also be valuable in using models that require soils information, such as vegetation growth models.

It is the user's responsibility not to misuse the estimated soil properties, and the estimates should not be used where actual field measurements are more appropriate. However, the estimates should provide a reasonable approximation where measured data is not required.

Much of the following material was presented in part at the Reynolds Creek Technology Transfer Symposium. The primary reference for the text is Brakensiek, Rawls and Stephenson, 1984.

HYDROSOIL

A computer program, HYDROSOIL, developed by Rawls and Brakensiek (1985), computes soil water properties commonly used in hydrologic modeling. The computer code for this program is listed in Appendix 1 in both the FORTRAN and BASIC languages. HYDROSOIL produces estimates of eight soil water parameters dealing with water retention and hydraulic conductivity. They include 1/3 bar water content, 15 bar water content, saturated hydraulic conductivity, effective porosity, wetting front capillary pressure, a porosity index, residual water content, and bubbling pressure. The latter six parameters correspond to parameters in the Brooks and Corey water retention function (Brooks and Corey, 1964). HYDROSOIL requires input of porosity, percent sand, and percent clay. A sample output from the program is given in Illustration 1.

APPLICATION TO THE SCS CURVE NUMBER METHOD

The SCS curve number method (SCS, 1972) has been widely used within the BLM and by many other agencies. One of the major problems in the use of the method is selection of the hydrologic soil group (HSG) and runoff curve number. Wood and Blackburn (1984) indicated that the hydrologic soil groupings should be "greatly modified" for use in arid and semiarid rangelands, especially to make more use of surface soil properties such as coarse fragments. Selection of the runoff curve number is one of the most important steps in using the method; however, there are few selection techniques that minimize variabilities among different users. The following sections describe: a method for consistently determining the HSG; methods for coarse, compacted, and frozen soils; and an alternative method for choosing a runoff curve number.

REYNOLDS CREEK HYDROLOGIC SOIL GROUP (HSG) PROCEDURES

The procedure developed by the ARS at Reynolds Creek for determining the HSG is based on knowing the percent sand and clay, and soil porosity.

The first step is to determine the porosity by using a value for moist bulk density. The moist bulk density can be found in many soil surveys or can be obtained through the Soils Information Retrieval System (SIRS) system (see section "Obtaining Soils Survey Information").

If the moist bulk density is not given, the porosity can be determined as follows:

1 - Enter Illustration 2 with the percent sand and clay and read the mineral bulk density.

The percent sand can be calculated from soils survey data/SIRS/SOILS-5 as:

$$Z5 = 100 - \frac{100\ I}{G} \qquad (1)$$

where

I = percent material <75 mm passing sieve #200 (I).

G = percent material <75 mm passing sieve #10

2 - Use the equation in Illustration 2 to calculate the Soil Bulk Density (SBD) with an appropriate percent of organic matter (OM).

3 - Calculate the total porosity as,

$$\text{Porosity} = 1 - \text{SBD}/2.65. \qquad (2)$$

Enter the HYDROSOIL program shown in Appendix 1 with the percent sand and clay, and porosity to determine the fine earth fabric saturated conductivity, KS. For determining the HSG, only the KS from the output is needed.

With KS known, determine the HSG from Illustration 3. Rangeland soils may require a modification due to conditions, such as stone or coarse fragment content, soil compaction, or frozen soils. These modifications are considered in the next section. The saturated conductivity limits for A, B, C, and D were taken from Musgrave (1955).

Coarse Materials

Rangeland soils, such as those on the Reynolds Creek Watershed, contain significant amounts of coarse fragments. From work by Bouwer and Rice (1983), and unpublished SCS SIRS/SOILS-5 based equations developed by Grossman (1983), a relationship was developed for calculating the soil porosity for the bulk soil containing coarse fragments,

$$K_c = \left(1 - \frac{Z1}{100}\right) / \left(\frac{1}{p} - \frac{Z1}{100}\right) \qquad (3)$$

where

K_c = the bulk soil porosity (with coarse fragments),

p = fine earth fabric, <2 mm, porosity, and

Z1 = percent by weight of the soil material >2 mm and <250 mm,

where Z1 is calculated by equation (4):

$$Z1 = E + \left(1 - \frac{E}{100}\right)(100 - G) , \qquad (4)$$

where

E = percent fraction >75 mm (E),
G = percent material <75 mm passing sieve #10 (G),

The value of p is the porosity determined from Illustration 2 by the procedure described above or taken from soils data file using SIRS/SOILS-5 based equation (Appendix 2).

Equation (5) was derived from the results of Bouwer and Rice (1983). The saturated conductivity of the soil containing coarse fragments, Kc, can be calculated from the conductivity of the fine earth fraction, KS, and the percent by weight of coarse fragments, Z1. If Z1 is not known it is calculated by equation (1).

$$K_c = \left(1 - \frac{Z1}{100}\right) KS \qquad (5)$$

The value of K_c is entered in Illustration 3 and a hydrologic soil group is determined for the bulk soil. The HYDROSOIL computer program can be entered with p to determine bulk soil properties other than the saturated hydraulic conductivity, which is determined by equation (5). Equation (5) is also similar to one derived by Peck and Watson (1979). Additional research on gravels in soils is presented by Dunn and Mehuys (1984).

Compacted Soils

Soil bulk densities can change as a function of land use which induce compaction. As the bulk density increases, the bulk soil porosity will decrease, which may change the HSG. The Reynolds Creek procedure is simply to change the original bulk density by the percent change and compute a new porosity. The HYDROSOIL program in Appendix 1 is entered with a new porosity, and the calculated KS value is used in Illustration 3 to determine the HSG.

Frozen Soils

Frozen soil conditions frequently occur on rangelands. The following procedure was developed by Lee (1983) from his study of a frozen soil. He related the ratio of the frozen soil saturated conductivity (KS)f to the unfrozen soil KS as a function of antecedent soil water content.

The antecedent soil water factor is expressed as a percent of field capacity. One-third bar water contents are also estimated in our computer program. Equations (6a,b) present Lee's relationships,

$$(KS)_f/KS = 1.89 - 0.023\ (\%\ \text{of FC}), \quad \%FC < 78\ \% \qquad (6a)$$

and

$$= 0.1 \quad , \quad \%F > 78\ \%. \qquad (6b)$$

For example, if it is estimated that the antecedent soil water content when the ground is frozen is 50 percent of field capacity, then by equation (5a)

$$(KS)_f/KS = 0.74.$$

Thus, if the original hydrologic soil group is "B", KS = 0.45 cm/hr, then

$$(KS)_f = 0.33\ \text{cm/hr}$$

and the HSG determined from Illustration 3 would be reduced to a "C" soil. Equations (6a,b) should be used very cautiously since they are based on laboratory tests of only one soil texture. However, they do indicate the hydrologic importance of frozen soils and give an estimation technique where frozen soil might be encountered.

Surface Rock

A thesis study by Dadkhah (1979) indicated that rock cover on the soil surface, from 0 percent to 20 percent, decreased the SCS curve number by nearly 10 percent. Apparently surface rock cover is a significant factor to consider on rangeland curve number hydrology, but more research is needed to quantify its effect. The same thesis study also investigated the interactions of rock cover, vegetation cover, and soil compaction.

Standard SCS procedures for determining rangeland CN's are given in Tables 8.1, 8.2, and 9.1 (see Illustration 4) of the SCS Hydrology Handbook (SCS 1972).

The Reynolds Creek procedure uses the KS parameter directly rather than the hydrologic soil group. The ARS developed Illustration 5 by combining SCS Tables 8.1, 8.2, and 9.1 (Illustration 4) and Illustration 3. Based on SCS Table 8.2, the cover classes were defined as shown in Illustration 5 for bare, poor, fair, and good cover. The lines in Illustration 5 were oriented with the four points in SCS Table 9.1 representing the curve numbers for a bare, poor, fair and good HC plotted versus the mid-point KS for each HSG. Illustration 5 would be entered with the estimated KS value and an estimated hydrologic condition (HC), i.e., cover class. For interpolation between classes, the ARS developed the following equation, assuming the average cover percent shown in Illustration 5 for each class.

$$CN = 96.38 - 0.158(C) - 19.84(KS) - 0.397(KS)(C) \qquad (7)$$

where

CN = Curve Number,
C = total cover in percent, and
KS = saturated conductivity, cm/hr.

The preceding procedure allows a user to use soil texture data to arrive at an estimate of KS. When the percent cover is included in equation (7), the curve number can be estimated with much more consistency between users. This does not mean that the estimated curve number value is better than produced from other methods, only more reproducible.

APPLICATION TO HYDROLOGY AND GROUND-WATER MODELS

More computer models are becoming available to Bureau employees. Several of the computer programs currently available on the Bureau's Honeywell DPS8 require the knowledge of hydrologic soil group and SCS runoff curve numbers (Moore, 1984). Most of the advanced surface water models, such as the Simulator for Water Resources in Rural Basins, (Arnold and Williams, 1985); the CREAMS model, (Knisel, 1980); the Simulation of Production and Utilization on Rangelands--SPUR, (USDA, 1983); and the Erosion Productivity Impact Calculator, (Williams, 1983), require a minimum of hydraulic conductivity and soil water properties. Many of the ground-water analysis models require knowledge of the wilting point, available water capacity, saturated hydraulic conductivity, porosity, effective porosity, bulk density and other properties. The Ekalaka Rangeland Hydrology and Yield Model (Wight, 1983) currently available on the Bureau's Honeywell, also requires some of these types of data. Gebhardt, 1985, presented applications to Bureau problems using some of the models under development.

In the future, the availability of micro computers will make models more available to Bureau personnel. Specialists will be able to analyze more than ever before. Estimates of soil properties can allow the specialist to generally determine such things as erosion, runoff, plant production, sedimentation, groundwater movement, and subsurface contaminant transport. In addition to the HYDROSOIL program, the tables in Appendix 3 contain summarized soil properties by texture class that are based on the work by Rawls et al. 1982, and were taken from Lane and Stone, 1983. General determinations from HYDROSOIL can often reduce or eliminate unnecessary field investigations and data collection. Provided that estimated soil water properties are used within their limitations, the methods presented above can be very useful.

OBTAINING SOILS SURVEY INFORMATION

General and detailed soils data usually come from published soil surveys. Where published surveys are not available, the detailed properties of soils may be obtained by soils series through the Soils Information Retrieval System (SIRS) provided the soil has been mapped and correlated according to the national standards. The SIRS system is an interactive computer service operated in cooperation with the U.S. Army Corps of Engineers and the Soil Conservation Service. The data base is massive and can be accessed through any Bureau terminal equipped with communications and proper account information. Appendix 4 contains information on using the SIRS system.

EXAMPLES

Given: Reynolds Creek SIRS/SOILS-5 data for Searla soil series (id0929) cool

(1) <u>Find</u> - percent sand

Sand (%) = Z5 = 100 - 100 I/G

I = percent material <75 mm passing #200 sieve = 35 - 50 percent
G = percent material <75 mm passing #10 sieve = 60 - 80 percent.

Using the midpoint value for I and G

Sand (%) = 100 - 100 (42.5/70)
= 39 percent.

(2) <u>Find</u> - percent by weight of material >2 mm and <250 mm = Z1

$$Z1 = E + \left(1 - \frac{E}{100}\right)(100-G)$$

E = percent fraction >75 mm
G = percent material <75 mm passing the #10 sieve.

From SIRS/SOILS-5

E = 5 - 10 percent
G = 60 - 80 percent

$$Z1 = 7.5 + \left(1 - \frac{7.5}{100}\right)(100 - 70)$$

Z1 = 35 percent.

(3) <u>Find</u> - Hydrologic Soil Group

From the SIRS/SOILS-5, the percent clay (M) is 12 - 20 with the mid-value of 16 percent and the percent of sand (Z5) is 39 percent.

The measured moist bulk density (N) is 1.4 - 1.5 with a mid-value of 1.45.

From HYDROSOIL computer program

KS = 0.60 cm/hr.

Referring to Illustration 3, this soil is Hydrologic Soil Group B.

If we assume a total cover of 30 percent, the calculated curve number from equation (7) is CN = 72.

GLOSSARY

ANTECEDENT SOIL WATER CONTENT- The degree of wetness of a watershed at the beginning of a storm. In the SCS method, 3 levels of AMC are used:

AMC-I. Lowest runoff potential. The watershed soils are dry enough for satisfactory plowing or cultivation to take place.

AMC-II. The average condition.

AMC-III. Highest runoff potential. The watershed is practically saturated from antecedent rains.

BUBBLING PRESSURE- Used as Pb in the Brooks and Corey equation. It is a characteristic constant of the medium and is a measure of the maximum pore size forming a continuous network of flow channels within the medium. Approximately the minimum capillary pressure on the drainage cycle at which the non-wetting fluid is continuous.

BULK DENSITY- The ratio of soil mass to the bulk soil volume. Can be calculated as moist or dry bulk density. See Illustration 2.

EFFECTIVE POROSITY- The volume of interconnected pore space that water can be freely removed from. Calculated as porosity minus residual water content.

FINE EARTH FRACTION- The fraction of soil material less than 2 mm. diameter.

POROSITY- The volume of pore space expressed as a fraction of bulk volume of the porous medium.

POROSITY INDEX- Pore size distribution index. Can be any positive value, being small for media having a wide range of pore sizes and large for media with a relatively uniform pore size. Used in the Brooks and Corey equations.

RESIDUAL WATER CONTENT- Volume of water remaining in the pore space after water has been freely removed from the interconnected pore space.

SATURATED HYDRAULIC CONDUCTIVITY- The rate of water movement through a porous media at a saturated soil water content.

WATER CONTENT, 1/3 BAR- The water content at 1/3 bar tension, defines the soil's field capacity.

WATER CONTENT, 15 BAR- The water content at the 15 bar moisture tension that represent the wilting point of many plants. Rangeland plants may have wilting points that are better described at higher moisture tensions.

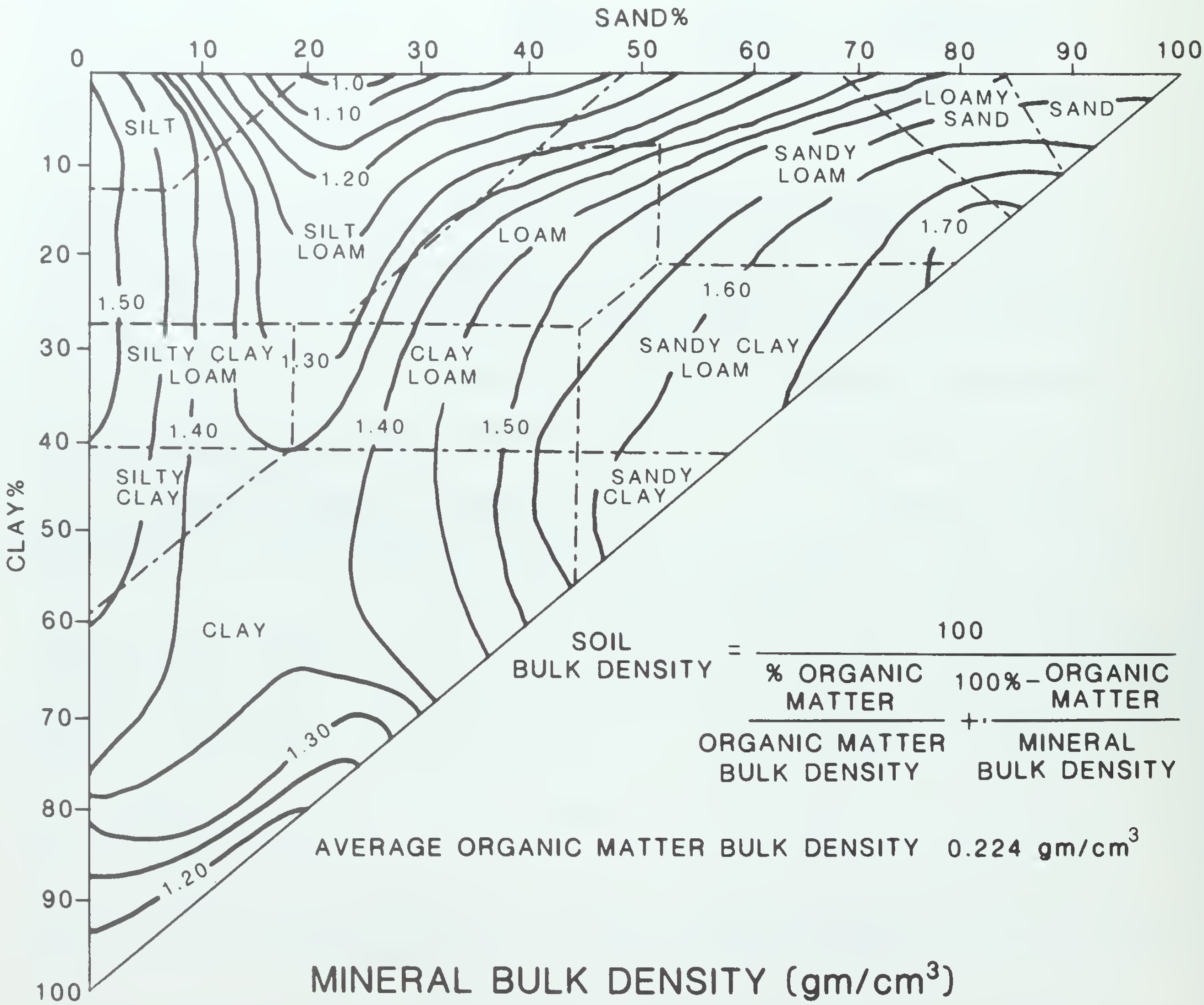
WATER HOLDING CAPACITY- The difference between water held at 1/3 bar (field capacity) and 15 bar (wilting point). Assumed to be the water available to plants.

WETTING FRONT CAPILLARY PRESSURE- The capillary pressure (tension) of the wet phase at the boundary of an air-water interface. Used in Green-Ampt equation.

HYDROSOIL Sample Output

```
RUN SOILS
    $ ENTER THE POROSITY:  0.45
    $ ENTER THE % OF SAND:  39
    $ ENTER THE % OF CLAY:  16


         POROSITY        % SAND        % CLAY
         0.45000          39.00         16.00

    EFFECTIVE POROSITY = 0.3788

    POROSITY INDEX     = 0.3460 (BROOKS AND COREY   )

    WETTING FRONT CAPILLARY PRESSURE =    21.1312 cm (GREEN AND AMPT   f)

    SATURATED HYDRAULIC CONDUCTIVITY =    0.59637 cm/hr (GREEN AND AMPT KS)

    ONE THIRD BAR WATER CONTENT      =    0.2331

    15 BAR WATER CONTENT             =    0.1135

    RESIDUAL WATER CONTENT           =    0.0710 (BROOKS AND COREY   r)

    BUBBLING PRESSURE                =   27.4790 cm (BROOKS AND COREY   b)

    $ WOULD YOU LIKE TO CALCULATE ANY MORE? (Y/N) N

FORTRAN STOP
```

Mineral Bulk Density Chart



MINERAL BULK DENSITY (gm/cm^3)

SCS Hydrologic Soil Groups

SCS hydrologic soil groups for saturated conductivity (KS) classes.

HSG (KS cm/hr)	Description
A (0.76-1.14)[1]	(Low runoff potential). Soils having high infiltration rates even when thoroughly wetted and consisting chiefly of deep, well to excessively drained sands or gravels. These soils have a high rate of water transmission.
B (0.38-0.76)	Soils having moderate infiltration rates when thoroughly wetted and consisting chiefly of moderately deep to deep, moderately well to well drained soils with moderately fine to moderately coarse textures. These soils have a moderate rate of water transmission.
C (0.13-0.38)	Soils having slow infiltration rates when thoroughly wetted and consisting chiefly of soils with a layer than impedes downward movement of water, or soils with moderately fine to fine texture. These soils have a slow rate of water transmission.
D (0.0-0.13)	(High runoff potential). Soils having very slow infiltration rates when thoroughly wetted and consisting chiefly of clay soils with a high swelling potential, soils with a permanent high water table, soils with a claypan or clay layer at or near the surface, and shallow soils over nearly impervious material. These soils have a very slow rate of water transmission.

1/ It is assumed that a KS greater than 1.14 cm/hr is an "A" soil.

SCS Tables from Handbook

Table 8.1.--Classification of native pasture or range

Vegetative condition	Hydrologic condition
Heavily grazed. Has no mulch or has plant cover on less than 1/2 of the area.	Poor
Not heavily grazed. Has plant cover on 1/2 to 3/4 of the area.	Fair
Lightly grazed. Has plant cover on more than 3/4 of the area.	Good

Table 8.2.--Air-dry weight classification of native pasture or range

Cover density (percent)	Plant and litter air-dry weight (tons per acre): Less than 0.5	0.5 to 1.5	More than 1.5
Less than 50	Poor	Poor +	Fair
50 to 75	Poor +	Fair	Fair +
More than 75	Fair	Fair +	Good

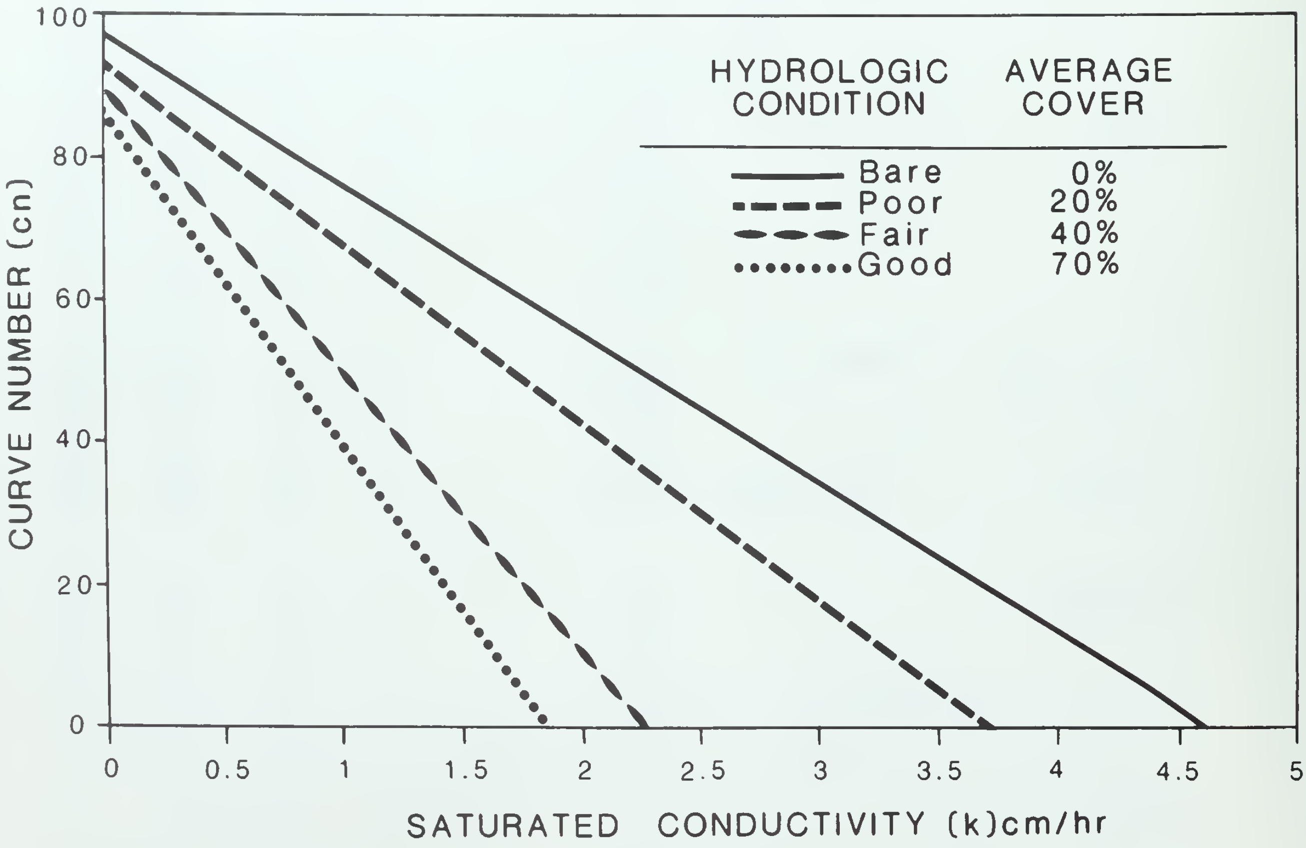
Table 9.1.--Runoff curve numbers for hydrologic soil-cover complexes

(Antecedent moisture condition II, and $I_a = 0.2\ S$)

Land use	Cover: Treatment or practice	Cover: Hydrologic condition	Hydrologic soil group: A	B	C	D
Fallow	Straight row	----	77	86	91	94
Row crops	"	Poor	72	81	88	91
	"	Good	67	78	85	89
	Contoured	Poor	70	79	84	88
	"	Good	65	75	82	86
	"and terraced	Poor	66	74	80	82
	" " "	Good	62	71	78	81
Small grain	Straight row	Poor	65	76	84	88
		Good	63	75	83	87
	Contoured	Poor	63	74	82	85
		Good	61	73	81	84
	"and terraced	Poor	61	72	79	82
		Good	59	70	78	81
Close-seeded legumes 1/ or rotation meadow	Straight row	Poor	66	77	85	89
	" "	Good	58	72	81	85
	Contoured	Poor	64	75	83	85
	"	Good	55	69	78	83
	"and terraced	Poor	63	73	80	83
	"and terraced	Good	51	67	76	80
Pasture or range		Poor	68	79	86	89
		Fair	49	69	79	84
		Good	39	61	74	80
	Contoured	Poor	47	67	81	88
	"	Fair	25	59	75	83
	"	Good	6	35	70	79
Meadow		Good	30	58	71	78
Woods		Poor	45	66	77	83
		Fair	36	60	73	79
		Good	25	55	70	77
Farmsteads		----	59	74	82	86
Roads (dirt) 2/		----	72	82	87	89
(hard surface) 2/		---	74	84	90	92

1/ Close-drilled or broadcast.
2/ Including right-of-way.

Rangeland Curve Numbers



Rangeland Curve Numbers as a function of saturated conductivity for cover classes.

HYDROSOIL COMPUTER CODES

```
      PROGRAM HYDROSOIL
C
C     **************************************************
C     *                                                *
C     *      PROGRAM TO FIND GREEN-AMPT PARAMETERS     *
C     *
*
C     *          WRITTEN BY: Terry Wadsworth
*
C     *                February 1984
*
C     *
*
C     *                  USDA-ARS
*
C     **************************************************
C
C  POR = POROSITY  PS = PERCENT SAND = % SAND  PC = PERCENT CLAY = % CLAY
C
      REAL*4 Ks,Yf,Qe,Qr,Yb,LAM
      CHARACTER*1 ANS
   10 WRITE(6,20)
   20 FORMAT(/,/,5X,'$ ENTER THE POROSITY: ',$)
      ACCEPT*, POR
      IF(POR .LT. 0.0 .OR. POR .GT. 1.0) GO TO 150
   30 WRITE(6,40)
   40 FORMAT(/,5X,'$ ENTER THE % OF SAND: ',$)
      ACCEPT*, SAND
      IF(SAND .LT. 5.0 .OR. SAND .GT. 70.0) GO TO 170
   50 WRITE(6,60)
   60 FORMAT(/,5X,'$ ENTER THE % OF CLAY: ',$)
      ACCEPT*, CLAY
      IF(CLAY .LT. 5.0 .OR. CLAY .GT. 60.0) GO TO 190
      PS=SAND
      PC=CLAY
C
C     EQUATIONS DESCRIBING GREEN-AMPT PARAMETER CHARTS
C
      Qe=0.01162-0.001473*PS-0.002236*PC+0.98402*POR+0.0000987*PC**2
     1+0.003616*PS*POR-0.010859*PC*POR-0.000096*PC**2*POR-0.002437*
     2POR**2*PS+0.0115395*POR**2*PC
C
      Yf=6.5309-7.32561*POR+0.001583*PC**2+3.809479*POR**2+0.000344*
     1PS*PC-0.049837*PS*POR+0.001608*PS**2*POR**2+0.001602*PC**2*
     2POR**2-0.0000136*PS**2*PC-0.003479*PC**2*POR-0.000799*PS**2*POR
C
      Yf = EXP(Yf)
C
      Ks=19.52348*POR-8.96847-0.028212*PC+0.00018107*PS**2-0.0094125*
     1PC**2-8.395215*POR**2+0.077718*PS*POR-0.00298*PS**2*POR**2-
     20.019492*PC**2*POR**2+0.0000173*PS**2*PC+0.02733*PC**2*POR+
     30.001434*PS**2*POR-0.0000035*PC**2*PS
```

```
C
      Ks = EXP(Ks)
C
      Qr=-0.0182482+0.00087269*PS+0.00513488*PC+0.02939286*POR
     1-0.00015395*PC**2-0.0010827*PS*POR-0.00018233*(PC**2)*
     2(POR**2)+0.00030703*(PC**2)*POR-0.0023584*(POR**2)*PC
C
      LAM=-0.7842831+0.0177544*PS-1.062498*POR-0.00005304*PS**2
     1-0.00273493*PC**2+1.11134946*POR**2-0.03088295*PS*POR
     2+0.00026587*(PS**2)*(POR**2)-0.00610522*(PC**2)*(POR**2)
     3-0.00000235*(PS**2)*PC+0.00798746*(PC**2)*POR-0.00674491
     4*(POR**2)*PC
C
      LAM = EXP(LAM)
C
      Yb=5.3396738+0.1845038*PC-2.48394546*POR-0.00213853*
     1PC**2-0.04356349*PS*POR-0.61745089*PC*POR+0.00143598
     2*(PS**2)*(POR**2)-0.00855375*(PC**2)*(POR**2)-0.00001282*
     3(PS**2)*PC+0.00895359*(PC**2)*POR-0.00072472*(PS**2)*POR
     4+0.0000054*(PC**2)*PS+0.50028060*(POR**2)*PC
C
      Yb = EXP(Yb)
C---------------
      BARTHD=.1535-.0018*PS+.0039*PC+.1943*POR
      BAR15 =.0370-.0004*PS+.0044*PC+.0482*POR
C
C     OUTPUT SECTION
C
      WRITE(6,70) POR,SAND,CLAY
  70  FORMAT(/,/,/,12X,'POROSITY',5X,'% SAND',5X,'% CLAY',/,
     112X,F7.5,6X,F6.2,5X,F6.2)
      WRITE(6,80) Qe
  80  FORMAT(/,/,5X,'EFFECTIVE POROSITY = ',F7.4)
      WRITE(6,85) LAM
  85  FORMAT(/,5X,'POROSITY INDEX     = ',F7.4)
      WRITE(6,90) Yf
  90  FORMAT(/,5X,'WETTING FRONT CAPILLARY PRESSURE = ',F10.4,' cm')
      WRITE(6,100) Ks
 100  FORMAT(/,5X,'SATURATED HYDRAULIC CONDUCTIVITY = ',F10.5,' cm/hr')
      WRITE(6,110) BARTHD
110   FORMAT(/,5X,'ONE THIRD BAR WATER CONTENT      = ',F10.4)
      WRITE(6,120) BAR15
120   FORMAT(/,5X,'15 BAR WATER CONTENT             = ',F10.4)
      WRITE(6,125) Qr
125   FORMAT(/,5X,'RESIDUAL WATER CONTENT           = ',F10.4)
      WRITE(6,126) Yb
126   FORMAT(/,5X,'BUBBLING PRESURE                 = ',F10.4,' cm')
      WRITE(6,130)
 130  FORMAT(/,/,/,5X,'$ WOULD YOU LIKE TO CALCULATE ANY MORE?(y/n) ',$)
      READ(5,140) ANS
 140  FORMAT(A1)
      IF(ANS .EQ. 'Y' .OR. ANS .EQ. 'y') GO TO 10
      STOP
C
```

```
C     ERROR CHECKING
C
 150  WRITE(6,160)
 160  FORMAT(/,/,5X,'ERROR IN POROSITY,  value must be > 0 and < 1')
      GO TO 10
 170  WRITE(6,180)
 180  FORMAT(/,/,5X,'ERROR IN PERCENTAGE OF SAND, value must be > 5 and
     1 < 70')
      GO TO 30
 190  WRITE(6,200)
 200  FORMAT(/,/,5X,'ERROR IN PERCENTAGE OF CLAY, value must be > 5 and
     1 < 60')
      GO TO 50
      END
```

HYDROSOIL BASIC VERSION

```
  1 REM       ****************************************************
  2 REM       *                HYDROSOIL                          *
  3 REM       *     PROGRAM TO FIND GREEN-AMPT PARAMETERS         *
  4 REM       *   FORTRAN VERSION WRITTEN BY: Terry Wadsworth 2/84*
  5 REM       *     BASIC VERSION WRITTEN BY: KARL GEBHARDT 7/85  *
  6 REM       *                   USDA-ARS                        *
  7 REM       ****************************************************
  8 REM
  9 REM  POR = POROSITY  PS = PERCENT SAND = % SAND  PC= PERCENT CLAY = % CLAY
 10  INPUT" ENTER THE POROSITY: ",POR
 20  IF(POR < 0.0) GOTO 380
 30  IF(POR > 1.0) GOTO 380
 40  INPUT(" ENTER THE % OF SAND: ",SAND
 50  IF(SAND < 5.0)GOTO 390
 60  IF(SAND > 70.0) GOTO 390
 70  INPUT" ENTER THE % OF CLAY: ",CLAY
 80  IF(CLAY < 5.0 )GOTO 400
 90  IF(CLAY > 60.0) GOTO 400
100  PS=SAND
110  PC=CLAY

115   REM     EQUATIONS DESCRIBING GREEN-AMPT PARAMETER CHARTS

120   QE=0.01162-0.001473*PS-0.002236*PC+0.98402*POR+0.0000987*PC©2+
0.003616*PS*POR-0.010859*PC*POR-0.000096*PC©2*POR-0.002437*
POR©2*PS+0.0115395*POR©2*PC

130   YF=6.5309-7.32561*POR+0.001583*PC©2+3.809479*POR©2+0.000344*
PS*PC-0.049837*PS*POR+0.001608*PS©2*POR©2+0.001602*PC©2*
POR©2-0.0000136*PS©2*PC-0.003479*PC©2*POR-0.000799*PS©2*POR

135   YF = EXP(YF)

140   KS=19.52348*POR-8.96847-0.028212*PC+0.00018107*PS©2-0.0094125*
PC©2-8.395215*POR©2+0.077718*PS*POR-0.00298*PS©2*POR©2-
0.019492*PC©2*POR©2+0.0000173*PS©2*PC+0.02733*PC©2*POR+0.001434*
PS©2*POR-0.0000035*PC©2*PS

150   KS = EXP(KS)

160   QR=-0.0182482+0.00087269*PS+0.00513488*PC+0.02939286*POR-
0.00015395*PC©2-0.0010827*PS*POR-0.00018233*(PC©2)*
(POR©2)+0.00030703*(PC©2)*POR-0.0023584*(POR©2)*PC

170   LAM=-0.7842831+0.0177544*PS-1.062498*POR-0.00005304*PS©2-
0.00273493*PC©2+1.11134946*POR©2-0.03088295*PS*POR+
0.00026587*(PS©2)*(POR©2)-0.00610522*(PC©2)*(POR©2)-
0.00000235*(PS©2)*PC+0.00798746*(PC©2)*POR-0.00674491*
(POR©2)*PC
```

```
180   LAM = EXP(LAM)

190  YB=5.3396738+0.1845038*PC-2.48394546*POR-0.00213853*
PC©2-0.04356349*PS*POR-0.61745089*PC*POR+0.00143598*
(PS©2)*(POR©2)-0.00855375*(PC©2)*(POR©2)-0.00001282*
(PS©2)*PC+0.00895359*(PC©2)*POR-0.00072472*(PS©2)*POR+
0.0000054*(PC©2)*PS+0.50028060*(POR©2)*PC

200   YB = EXP(YB)

210   BARTHD=.1535-.0018*PS+.0039*PC+.1943*POR
220   BAR15 =.0370-.0004*PS+.0044*PC+.0482*POR

225   REM     OUTPUT SECTION

230   PRINT"POROSITY=";POR
240   PRINT"PERCENT SAND= ";SAND
250   PRINT"PERCENT CLAY= ";CLAY
255   PRINT
260   PRINT"EFFECTIVE POROSITY = ";QE
265   PRINT
270   PRINT" POROSITY INDEX     = ";LAM
275   PRINT
280   PRINT" WETTING FRONT CAPILLARY PRESSURE = ";YF
285   PRINT
290   PRINT " SATURATED HYDRAULIREM CONDUCTIVITY = ";KS
300   PRINT
310   PRINT" ONE THIRD BAR WATER CONTENT      = ";BARTHD
315   PRINT
320   PRINT" 15 BAR WATER CONTENT             = ";BAR15
325   PRINT
330   PRINT" RESIDUAL WATER CONTENT           = ";QR
335   PRINT
340   PRINT" BUBBLING PRESURE                 = ";YB
345   PRINT
350   INPUT"  WOULD YOU LIKE TO CALCULATE ANY MORE? (Y/N)",AN$
360   IF(AN$ = "Y") GOTO 10
370   END
375   REM     ERROR CHECKING

380   PRINT"ERROR IN POROSITY, VALUE >0 AND < 1":GOTO 10
390   PRINT"ERROR IN PERCENTAGE OF SAND, VALUE MUST BE > 5, < 70":GOTO 40
400   PRINT"ERROR IN PERCENTAGE OF CLAY, VALUE MUST BE > 5, < 60":GOTO 70
```

USE OF SOILS-5 FOR SOIL WATER PROPERTIES

Exerpted from Reynolds Creek Technology Transfer Symposium
D. L. Brakensiek and G. R. Stephenson,
USDA-Agricultural Research Service

The SCS Soils-5 file represents the largest U.S. soils data bank that is now available. In our previous session, we demonstrated use of SIRS to access Soils-5. We noted that the Soils-5 data file may not include important soil water properties. Tables 1 and 2 are expressions that have been derived by R.B. Grossman, National Soils Survey Laboratory, SCS, Lincoln, Nebraska, for calculating these quantities. He cautions that the exactness of these approximations may vary. Further, he cautions that they should only be used if measurements for particular properties are unavailable.

Table 1 contains a letter code for the soil property entries and a set of hypothetical values for those entries of concern. Table 2 lists the calculated quantities, gives the composition base, the units, the calculating relationship, and the value obtained using input values from Table 1.

Table 3 presents a printout for the Searla soil series obtained through the SIRS system. For infiltration and curve number (CN) hydrologic computations, certain additional soil properties are needed which are not available on SOILS 5. Specifically, these are

percent of fragments 250 mm, 2 mm by weight (Z1),

and

percent sand (Z5).

These can be calculated from the Grossman expressions (Table 2),

$$Z1 = E + \left[\left(1 - \frac{E}{100}\right)(100 - G)\right],$$

where

E = percent fraction greater than 3 inches,

and

G = percent material less than 3 inches passing sieve #10.

Using the mid-values from Table 3,

$$Z1 = 7.5 + \left[\left(1 - \frac{7.5}{100}\right)(100 - 70)\right] = 35\%,$$

$$Z5 = 100 - \frac{100\ I}{G}$$

where

I = percent material less than 3 inches passing sieve #200, and

$$Z5 = 100 - 100\left(\frac{42.5}{70}\right) = 39\%.$$

Table 1. Symbol Designation and Numerical Values Assigned for Computation of Derivative Quantities from the Property Table of the Soil Survey Interpretation Sheet.

Quantity	Letter Designation	Value	Units
Soil Property Table			
Depth	A		
Texture	B		
UNIFIED	C		
AASHO	D		
>3 inches	E	20	Pct
Pass 4	F	70	Pct
Pass 10	G	50	Pct
Pass 40	H	45	Pct
Pass 200	I	35	Pct
Liquid Limit	J	45	Pct
Plasticity Index	K	25	Pct
Depth	L		
Clay	M	45	Pct
Bulk Density	N	1.40	Mg/m^3 a/
Permeability	O		
Available Water Capacity	P	0.10	
Reaction	Q		
Salinity	R	4-8, use 6	dS/m b/
Shrink-Swell	S	.03-.06, use .05	
Erosional K	T		
Erosional T	U		
Wind Erosion Group	V		
Organic Matter	W	6	Pct
Corrosion, Steel	X		
Corrosion, Concrete	Y		
Other			
Liquid Limit Versus Clay Relationship			
Intercept, a		+2	Pct
Slope, b		0.8	Pct
Air Filled Porosity for <2 mm, AFP		5	Pct
Coefficient Linear Extensibility, COLE		.05	
Intermediate Water Content of <2 mm, IWC		25	Pct

Particle Density, Dp, Dp >2, Dp

Dp is for <2 mm, Dp >2 for the >2, and Dp for <250. Calculate Z25, Z26 if W >5 percent for the composition base; otherwise use 2.65 Mg/m^3. If taxa indicates high extractable iron or volcanic ejecta of rhyolitic composition, consult Supplement 6.

SALT

Assume that 10-fold entry R. Or, enter with R into figure 14 or USDA Handbook No. 60.

a/ Megagram per cubic meter. Same numerical value as g/cm.

b/ Decisiemen per meter. Same numerical value as millimohs per cm.

Table 2. Derived Quantities from the
Soil Property Table of the Soil Survey Interpretation Sheet

No.	Quantity	Composition Base mm	Units	Calculating Relationship†	Illustrative Values
Z1	> 2 mm Weight	< 250	Pct	$E + \left[\left[1 - \frac{E}{100}\right][100 - G]\right]$	60
Z2	> 2 mm Volume	< 250	Pct	$\frac{Z1}{D_{p>2}} \left[\frac{100}{\frac{Z1}{D_{p>2}} + \frac{100-Z1}{N}}\right]$	44
Z3	Liquid Limit, <2 mm	< 2	Pct	$\frac{J \times II}{G}$	41
Z4	Clay from Liquid Limit	< 2	Pct	$\frac{Z3 - a}{b}$ where a and b are, respectively, the intercept and the slope of the liquid limit-clay relationship assumed.	49
Z5	Sand	< 2	Pct	$100 - \frac{100\ I}{G}$	30
Z6	Silt	< 2	Pct	$\frac{100\ I}{G} - (M \text{ or } Z4)$	For M, 25; for Z_4, 21
Z7	1,500 kPa, Weight	< 2	Pct	0.4 (M or Z4)	For M, 18; for Z_4, 20
Z8	1,500 kPa, Weight	< 250	Pct	$Z7 \left[1 - \frac{Z1}{100}\right]$	For M, 7; for Z_4, 8
Z9	1,500 kPa, Volume	< 2	Pct	Z7 x N	For M, 25; for Z_4, 28
Z10	1,500 kPa, Volume	< 250	Pct	$Z9 \left[1 - \frac{Z2}{100}\right]$	For M, 14; for Z_4, 16
Z11	Field Capacity, Weight	< 2	Pct	$\frac{100\ P}{\left[1 - \frac{Z2}{100}\right] N} + Z7$	For M, 31; for Z_4, 33

Table 2. (continued)

No.	Quantity	Composition Base mm	Units	Calculating Relationship †	Illustrative Values
Z12	Field Capacity Weight	< 250	Pct	$\left[\frac{100P \times Z_{26}}{Z15}\right] + Z8$	For M, 21; for Z4, 22
				Or, $Z28 - AFP \left[1 - \frac{Z2}{100}\right]$	20
Z13	Field Capacity, Volume	< 2	Pct	$\frac{100P}{1 - \frac{Z2}{100}} + Z9$	For M, 43; for Z_4, 46
				Or, Z27 - AFP	41
Z14	Field Capacity, Volume	< 250	Pct	100P + Z10	For M, 24; for Z_4, 26
				Or, $Z28 - AFP \left[1 - \frac{Z2}{100}\right]$	23
Z15	Bulk Density, Field Capacity	< 250	Mg/m^3	$\left[1 - \frac{Z2}{100}\right] N + \left[\frac{Z2}{100} \times D_{p} > 2\right]$	1.95
Z16	Bulk Density, Field Capacity, Pass No. 4	< 4	Mg/m^3	$1/\left[\frac{F - G}{F \times D_p > 2} + \frac{G}{F \times N}\right]$	1.62
Z17	Bulk Density, Dry, Excluding Cracks	< 2	Mg/m^3	$\left[\frac{COLE}{1 - \frac{Z2}{100}} + 1\right]^3 N$	1.81
Z18	Bulk Density, Dry, Excluding Cracks	< 250	Mg/m^3	$(COLE + 1)^3\ Z15$	2.26
Z19	Bulk Density, Intermediate Moisture, Excluding Cracks	< 2	Mg/m^3	$\frac{N + (Z17 - N)\ (1WC - [0.6 \times Z7])}{Z11 - (0.6 \times Z7)}$	For M, 1.69; for Z4, 1.64

Table 2 (continued)

No.	Quantity	Composition Base mm	Units	Calculating Relationship †	Illustrative Values
Z20	Bulk Density, Intermediate Moisture, Excluding Cracks	< 250	Mg/m^3	$Z15 + \frac{(Z18 - Z15)\ IWC\ 1 - \frac{Z1}{100} - (0.6 \times Z8)}{Z12 - (0.6 \times Z8)}$	2.06
Z21	Bulk Density, Moisture Unspecified, Including Cracks	< 2	Mg/m^3	$N \times \left[\frac{Z17 \text{ or } Z19}{N}\right]^{1/3}$	1.53 for Z17
Z22	Bulk Density, Moisture Unspecified Including Cracks	< 250	Mg/m^3	$Z15 \times \left[\frac{Z18 \text{ or } Z20}{Z15}\right]^{1/3}$	2.05 for Z18
Z23	Bulk Density, Inclusive of Water Weight	< 2	Mg/m^3	$N + \left[\frac{Z9,\ Z13, \text{ or } Z27}{100}\right]$	For Z9, 1.65; for Z27, 1.86
Z24	Bulk Density, Inclusive of Unspecified Water Weight	< 250	Mg/m^3	$Z15 + \frac{Z10,\ Z14 \text{ or } Z28}{100}$	For Z10, 2.09; for Z28, 2.21
Z25	Particle Density	< 2	Mg/m^3	$2.65 \left[1 - \frac{W}{100}\right] + \frac{1.4\ W}{100}$	2.58
Z26	Particle Density	< 250	$Mg/3^3$	$2.65 \left[\frac{100 - W \left[1 - \frac{Z1}{100}\right]}{100}\right] + \frac{1.4W}{100} \left(1 - \frac{Z1}{100}\right)$	2.65
Z27	Total Porosity, Field Capacity	< 2	Pct	$\left(1 - \frac{N}{Z25}\right) 100$	46
Z28	Total Porosity, Field Capacity	< 250	Pct	$\left(1 - \frac{Z15}{Z26}\right) 100$	26
Z29	Void Ratio, Field Capacity	< 2		$\frac{Z25}{N} - 1$	0.84

Table 2. (continued).

No.	Quantity	Composition Base mm	Units	Calculating Relationship‡	Illustrative Values
Z30	Void Ratio, Field Capacity	< 250		$\frac{Z26}{Z15} - 1$	0.37
Z31	Saturation Percentage	< 2	Pct	Z3 + 5	46
Z32	Maximum Solution Sulfate	< 2	p/m	$\frac{Z31 \times SALT}{2}$	1,400

† Symbols are defined and numerical values given in Table 1.

‡ Calculated from values in Table 1. If more than one means of calculation, the values listed are in order of the alternatives as given in the calculating relationship.

§ Millimoles of charge per kilogram.

Table 3. Soils-5 File for Searla Soil Series.

--*-*-*-*-*-*-*-*-*-*

searla (id0929)cool

mlra(s): 25
rev. th,ghl , 12-82
calcic argixerolls, loamy-skeletal, mixed, frigid

the searla series consists of very deep well drained soils that formed in colluvium from sedimentary rocks on mountains. elevation is 5500 to 6900 feet. aap is 14 to 16 ihes. mast is 42 to 45 f. ffs is 50 to 70 days. vegetation is mountain big sagebrush and bluebunch wheatgrass. typically the surface layer is brown gravelly loam 15 inches thick. the subsoil is yellowish brown very gravelly clay loam to 32 inches. the substratum is white very gravelly loam and very pale brown very gravelly sandy loam to 60 inches. slopes are 30 to 60 percent.

--*-*-*-*-*-*-*-*-*-*

searla (id0929)cool

A depth (in.)	B texture	C unified	D aashto	E fract > 3in (pct)	F percent of material less than 3 in passing sieve no. 4	G 10	H 40	I 200	J liquid limit	K plast'y index	M clay %<2mm	N moist bulk density (g/cm3)
0-15	gr-l	sm-sc, gm-gc	a-4	5-10	65-85	60-80	45-60	35-50	25-30	5-10	12-20	1.40-1.50
15-32	grv-cl	gc	a-2	5-15	45-60	35-50	25-40	20-35	30-40	10-15	27-35	1.40-1.50
32-60	grv-l, grv-sl	gm-gc	a-1, a-2	0-15	35-60	25-50	15-35	10-30	25-30	5-10	10-22	1.50-1.60

O permea-bility (in/hr)	P available water (in/in)	Q soil reaction (ph)	R salinity mmhos/cm	S shrink-swell	T erosion factors k	U t	V wind erod. group	W organic matter (pct)
0.6-2.0	0.13-0.16	6.6-7.3	-	low	.15	2	6	2-4
0.2-0.6	0.10-0.13	6.6-7.3	-	low	.10			
0.6-2.0	0.05-0.09	7.4-8.4	< 2	low	.05			

SELECTED SOIL PROPERTIES BASED ON TEXTURE

Exerpted from Lane and Stone, 1983.

Table 1.--Selected soil properties based on soil textural class.

Soil texture class	Representative composition			Saturated hydraulic conductivity (cm/hr)			Bare soil evaporation parameter c(mm/day 1/2)		
	Clay	Silt	Sand	Avg	Low	High	Avg	Low	High
Sand	3	7	90	23.	11.7	43.2	3.3	3.05	3.32
Loamy sand	5	15	80	6.1	3.6	11.7	3.3	3.05	3.32
Sandy loam	10	20	70	2.2	1.7	3.6	3.5	3.10	4.06
Loam	20	40	40	1.3	.91	1.7	4.5	3.20	4.57
Silt loam	15	65	20	.69	.46	.91	4.5	3.20	4.57
Silt	5	87	8	.51	.30	.61	4.0	3.15	4.40
Sandy clay loam	30	10	60	.30	.25	.46	3.8	3.15	4.32
Clay loam	35	35	30	.20	.19	.25	3.8	3.15	4.32
Silty clay loam	35	55	10	.18	.15	.19	3.8	3.15	4.32
Sandy clay	45	5	50	.13	.11	.15	3.4	3.10	3.56
Silty clay	45	50	5	.10	.09	.11	3.5	3.10	3.81
Clay	65	20	15	.08	.06	.09	3.4	3.10	3.56

Table 2.--Porosity and water holding capacity (water content in % by volume) based on soil textural class.

Soil texture class	Total porosity			-1/3 Bar Water holding capacity			-15 Bar Water holding capacity		
	Avg	Low	High	Avg	Low	High	Avg	Low	High
Sand	41	39	43	9	7	15	3	2	6
Loamy sand	43	39	45	12	10	20	6	4	8
Sandy loam	45	39	52	20	14	29	9	5	12
Loam	47	45	52	26	20	36	12	9	18
Silt loam	50	49	55	31	20	36	13	7	20
Silt	51	49	55	28	26	30	9	6	12
Sandy clay loam	42	38	45	27	17	34	17	11	21
Clay loam	47	40	51	34	29	38	20	16	24
Silty clay loam	47	46	51	36	33	40	21	18	24
Sandy clay	42	40	44	31	27	40	21	18	30
Silty clay	48	46	49	40	35	46	27	23	32
Clay	49	44	52	42	34	49	29	23	38

SOIL INFORMATION RETRIEVAL SYSTEM

Much of the following information can be obtained from the publication:

An Interactive Soils Information System Users Manual
CERL TR-N-163
Author: William D Goran
U.S. Army Construction Engineering Research Laboratory
P.O. Box 4005
Champaign, IL 61820

The Soil Information Retrieval System (SIRS) is an interactive, user-friendly computer based system for retrieving soils data. Basically, all data available in published soil surveys are being placed in the SIRS system and are being updated on a regular basis. Figure 1 shows the operation of SIRS.

Tables 1 and 2 (taken from the Reynolds Creek Technology Transfer Symposium) are examples of SIRS output of soils properties for the Demast and Searla soil series. Such soils properties can be used in the Grossman expressions, Appendix 2, to compute many other soils properties relating to engineering and hydrology.

The following items are needed to access the SIRS system.

1. A valid account number and password. (For information, contact FTS 343-1369).

2. A computer terminal equipped with telecommunications at 300 or 1200 baud.

3. Valid soil series name.

Soils Information Retrieval System

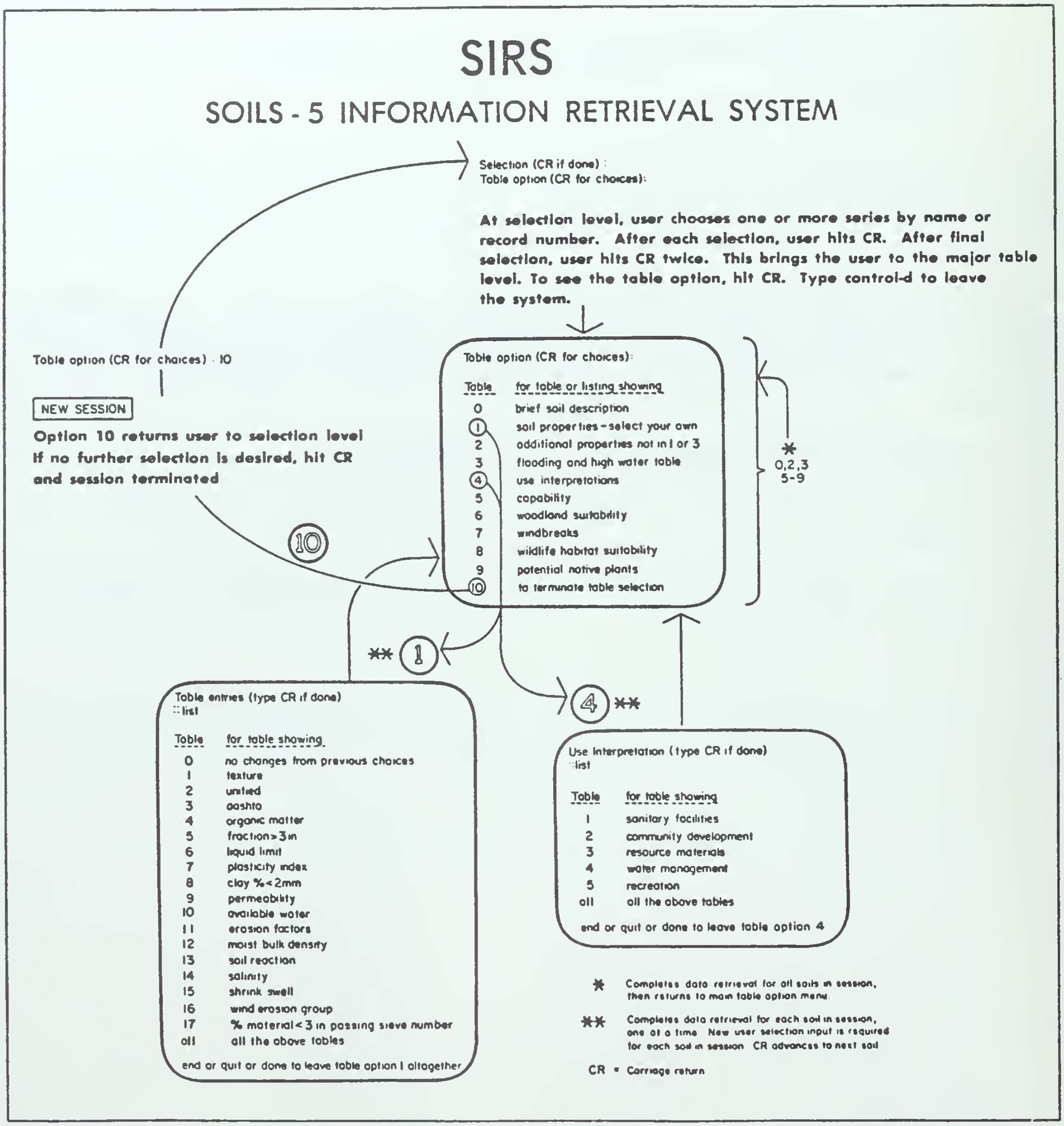


Figure 1. Operation of SIRS.

Table 1. Output for Demast series; Table 0 and Table 1 selections from main option menu.

--*-*-*-*-*-*-*-*-*

demast (id0331)

mlra(s): 43 , 25
rev. lr,md , 2-82
argic pachic cryoborolls, fine-loamy, mixed

demast series consists of well drained soils formed in basalt residuum on foothills and mountains. elevation is 5000 to 8000 feet. vegetation is forest. map is 18 to inches. mast is 35 to 43 f. ffs is 60 to 80 days. typically surface layer has a 2.5 inch organic layer over very dark grayish-brown loam to 10 inches over very dark grayish-brown gravelly loam to 23 inches. the subsoil is dark brown and brown gravelly light clay loam over bedrock at 58 inches. slopes are 10 to 80 percent.

--*-*-*-*-*-*-*-*-*

demast (id0331)

depth (in.)	texture	unified	aashto	fract > 3in (pct)	percent of material less than 3 in passing sieve no. 4	10	40	200	liquid limit	plast'y index	clay %<2mm
0-10	l	cl-ml	a-4	0-5	95-100	90-100	75-95	55-	25-30	5-10	18-25
0-10	gr-l	ml, sm-sc	a-4	0-10	70-90	60-80	55-75	40-60	25-30	5-10	18-25
10-23	gr-l	cl-ml, sm-sc	a-4	5-15	80-90	70-85	60-80	45-65	25-30	5-10	18-25
23-58	gr-cl, gr-l, cb-l	cl	a-6	15-35	75-85	70-80	65-80	50-60	30-35	10-15	22-30
58	wb										

moist bulk density (g/cm3)	permea-bility (in/hr)	available water (in/in)	soil reaction (ph)	salinity mmhos/cm	shrink-swell	erosion factors k	t	wind erod. group	organic matter (pct)
-	0.6-2.0	0.11-0.18	5.6-7.3	-	low	.24	3	6	2-4
-	0.6-2.0	0.12-0.14	5.6-7.3	-	low	.24	3	6	2-4
-	0.6-2.0	0.11-0.13	5.6-7.3	-	low	.24			
-	0.2-0.6	0.13-0.15	5.6-7.3	-	moderate	.20			

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Table 2. Output for Searla cool series; Table 0 and Table 1 selections from main option menu.

--*-*-*-*-*-*-*-*-*

searla (id0929)cool

mlra(s): 25
rev. th,ghl , 12-82
calcic argixerolls, loamy-skeletal, mixed, frigid

the searla series consists of very deep well drained soils that formed in colluvium from sedimentary rocks on mountains. elevation is 5500 to 6900 feet. aap is 14 to 16 ihes. mast is 42 to 45 f. ffs is 50 to 70 days. vegetation is mountain big sagebrush and bluebunch wheatgrass. typically the surface layer is brown gravelly loam 15 inches thick. the subsoil is yellowish brown very gravelly clay loam to 32 inches. the substratum is white very gravelly loam and very pale brown very gravelly sandy loam to 60 inches. slopes are 30 to 60 percent.

--*-*-*-*-*-*-*-*-*

searla (id0929)cool

depth (in.)	texture	unified	aashto	fract > 3in (pct)	percent of material less than 3 in passing sieve no. 4	10	40	200	liquid limit	plast'y index	clay %<2mm	moist bulk density (g/cm3)
0-15	gr-l	sm-sc, gm-gc	a-4	5-10	65-85	60-80	45-60	35-50	25-30	5-10	12-20	1.40-1.50
15-32	grv-cl	gc	a-2	5-15	45-60	35-50	25-40	20-35	30-40	10-15	27-35	1.40-1.50
32-60	grv-l, grv-sl	gm-gc	a-1, a-2	0-15	35-60	25-50	15-35	10-30	25-30	5-10	10-22	1.50-1.60

permea-bility (in/hr)	available water (in/in)	soil reaction (ph)	salinity mmhos/cm	shrink-swell	erosion factors k	t	wind erod. group	organic matter (pct)
0.6-2.0	0.13-0.16	6.6-7.3	-	low	.15	2	6	2-4
0.2-0.6	0.10-0.13	6.6-7.3	-	low	.10			
0.6-2.0	0.05-0.09	7.4-8.4	< 2	low	.05			

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15. Supplementary Notes

16. Abstract (Limit: 200 words)

This technical note provides resource specialists with tools for estimating soil properties required by many of the state-of-the-art hydrology, erosion, and sediment yield procedures and computer models. Some of the hydrologic soil properties will also be valuable in using models that require soils information, such as vegetation growth models.

It is the user's responsibility not to misuse the estimated soil properties, and the estimates should not be used where actual field measurements are more appropriate. However, the estimates should provide a reasonable approximation where measured data is not required.

Much of the following material was presented in part at the Reynolds Creek Technology Transfer Symposium. The primary reference for the text is Brakensiek, Rawls and Stephenson, 1984.

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